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RESPONDING MAINTAINED BY INTERMITTENT REINFORCEMENT: IMPLICATIONS FOR THE USE OF EXTINCTION WITH PROBLEM BEHAVIOR IN CLINICAL SETTINGS

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Results of basic research have demonstrated that behavior maintained on an intermittent schedule of reinforcement (INT) will be extinguished more slowly than behavior maintained on a continuous schedule (CRF). Although these findings suggest that problem behaviors may be difficult to treat with extinction if they have been maintained on INT rather than on CRF schedules, few applied studies have examined this phenomenon with human behavior in clinical settings. The purpose of this study was to determine whether problem behavior maintained on CRF schedules would be extinguished more rapidly than behavior maintained on INT schedules. Three individuals diagnosed with profound mental retardation participated after results of pretreatment functional analyses had identified the sources of reinforcement that were maintaining their self-injury, aggression, or disruption. Subjects were exposed to extinction following baseline conditions with CRF or INT schedules alternated within reversal or multielement designs. Results suggested that problem behaviors may not be more difficult to treat with extinction if they have been maintained on INT rather than CRF schedules. However, switching from an INT to a CRF schedule prior to extinction may lower the baseline response rate as well as the total number of responses exhibited during extinction.

DESCRIPTORS: aggression, disruption, extinction, intermittent reinforcement, partial-reinforcement extinction effect, reinforcement schedule, resistance to extinction, self-injurious behavior

Results of basic research conducted with both humans and nonhumans indicate that exposure to intermittent (INT) schedules of reinforcement can increase resistance to extinction, a phenomenon that has been termed the *partial-reinforcement extinction effect* or PREE (see Kimble, 1961, and Mackintosh, 1974, for reviews). Behavioral persistence during extinction following reinforcement with INT versus continuous (CRF) schedules has been measured in several ways,

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including response rate (e.g., Cowen & Walters, 1963) or number of responses (e.g., Bijou, 1958; Hearst, 1961) during extinction, or amount of time to meet a specified extinction criterion such as no responses for 5 min (e.g., Perin, 1942). Using one or more of these measures, basic researchers have demonstrated the PREE across a variety of subjects, responses, and reinforcement schedules.

As a result, the PREE often is considered to be "one of the fundamental rules governing the application of learning principles to practical problems" (Pittenger & Pavlik, 1988, p. 2). An important implication drawn from studies on the PREE suggests that problem behaviors may be difficult to treat with extinction if they have been maintained on INT rather than on CRF schedules, which is often the case in the natural environment. Some authors have even suggested that, due to potential difficulties generated by the PREE, extinction should not be used as treatment for severe behavior problems (e.g., LaVigna & Donnellan, 1986). However, extinction may be a critical component of effective treatment for many behavior disorders (Fisher et al., 1993; Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993; Wacker et al., 1990; Zarcone, Iwata, Smith, Mazaleski, & Lerman, 1994). Thus, it is somewhat surprising that no applied studies have examined the clinical significance of the PREE with problem behavior and that few studies have investigated the effects of INT schedules on other types of responses.

Kazdin and Polster (1973) reinforced the social interactions of 2 men diagnosed with mental retardation during daily break periods at a sheltered workshop and compared the effects of two reinforcement schedules on response maintenance during extinction. Both subjects initially received tokens following each break period for conversing with peers (CRF schedule), and their social interactions during the break periods rapidly decreased to near-zero levels when reinforcement was discontinued. Following extinction, 1 subject again received tokens on the CRF schedule for conversing with peers, and the other subject received tokens after either one or two of the three break periods (INT schedule). When exposed to extinction a second time, the subject who had received tokens on the CRF schedule exhibited few social interactions by the 2nd week of extinction, whereas the subject who had received tokens on the INT schedule showed no reduction in behavior across the 5 weeks of extinction. These results provide one of the few demonstrations of the PREE in an applied setting. However, the effect of INT reinforcement may have been partially a function of reinforcement delay, another variable that was included in the procedure (i.e., the subjects received reinforcement after the break period rather than following each interaction). When combined with INT schedules, reinforcement delay may enhance the PREE (Peterson, 1956). It is also possible that the results may simply have reflected different extinction rates for the 2 subjects.

Results of a study by Koegel and Rincover (1977) also suggested that INT schedules can facilitate behavioral maintenance in clinical settings. Four autistic children were taught to comply with instructions, and their performance was subsequently measured in a nontreatment setting. Results showed that a reinforcement schedule in which every fifth instance of appropriate behavior received reinforcement in the training setting (i.e., fixed-ratio [FR] 5) was associated with continued responding in the generalization setting with no apparent decrement for up to 500 trials. By contrast, CRF or FR 2 schedules in the training setting were associated with fairly rapid decreases in behavior in the generalization setting. However, 3 of the children were exposed to just one reinforcement schedule (CRF, FR 2, or

FR 5), and results of this between-subjects comparison may have reflected different extinction rates for the 3 subjects. Although the 4th child was exposed to two reinforcement schedules (FR 2 and FR 5), each schedule was paired with a different response; thus, results could reflect different extinction rates for the two types of behavior.

In another study, Baer, Blount, Detrich, and Stokes (1987) examined the effects of INT reinforcement schedules on the maintenance of correspondence between verbal and nonverbal snack choices in a daycare setting. Initially, the subject received reinforcement (e.g., hugs, stickers) for verbalizing healthy food choices prior to the daily snack period, a procedure that did not increase the amount of nutritious items actually selected during snack time. When the subject received reinforcement only if the presnack verbalizations matched the items chosen during snack time (reinforcement of correspondence), the number of healthy food items selected increased substantially. A reversal to the reinforcement of verbalizations was associated with a gradual reduction in the amount of nonverbal nutritious snack choices. Reinforcement for verbal-nonverbal correspondence was then reinstated, and the schedule was gradually thinned from 100% to 33% (i.e., reinforcement was delivered on 33% of the days) prior to another maintenance phase. During this second maintenance phase, the subject was asked to verbalize food choices but received no reinforcement for either verbal or nonverbal choices, and appropriate snack choice behavior was maintained for 17 experimental sessions conducted across a 7-week period. Although results of this study are consistent with a PREE interpretation, two other factors may have been responsible for the findings. First, a larger number of reinforcers was delivered prior to the second maintenance phase (i.e., when reinforcement was reinstated and gradually thinned), possibly enhancing resistance to extinction (Perin, 1942; Siegel & Foshee, 1953). Second, different procedures were implemented during the two maintenance phases. During the first maintenance phase (following the CRF schedule), reinforcement was delivered prior to snack time for correct verbalizations; during the second maintenance phase (following the INT schedule), no reinforcement was delivered for either verbal or nonverbal snack choices. In the conditions immediately preceding both maintenance phases, however, reinforcement was delivered after the snack period for verbal-nonverbal correspondence. As a result, the first maintenance phase contained a salient stimulus (reinforcer delivery for presnack verbalizations) that was absent from both the reinforcement and the second maintenance conditions. Accordingly, the subject's behavior may have maintained for a longer period of time during the second maintenance phase because the transition from reinforcement of correspondence to extinction was less obvious (i.e., more difficult to discriminate) than the transition from reinforcement to the first maintenance phase. In a similar study, Baer, Williams, Osnes, and Stokes (1984) obtained maintenance of verbal-nonverbal correspondence by simply delaying the reinforcement for verbalizations, and the authors concluded that delivery of the reinforcer immediately following verbalizations functioned to signal the termination of reinforcement for correspondence (i.e., extinction).

Results of the above studies appear to replicate those of basic research demonstrating that INT schedules can increase resistance to extinction; however, each study contained one or more additional variables that may have accounted for the outcomes. Thus, further studies are needed to investigate the clinical significance of the PREE, particularly with inappropriate behavior. Applied research on the PREE should also be con-

ducted because the relationship between reinforcement intermittence and resistance to extinction is somewhat complex. A brief discussion of several issues that have emerged in the basic literature and their relevance to applied research on the PREE is in order.

In most basic studies on the PREE, separate groups of subjects were exposed to different reinforcement schedules, and, after responding by individual subjects within each group was averaged, performance of the different groups was compared during extinction. However, this design may not be practical in applied research because the high degree of intersubject variability that is common among humans would require the use of large subject pools. (Humans generally have varied and extensive reinforcement histories prior to the study.) Furthermore, results of between-groups comparisons may not be directly relevant to the behavior of individuals (Sidman, 1960). For these reasons, applied studies on the PREE should use experimental designs that permit within-subject comparisons of responding during extinction.

In the basic laboratory, however, many attempts to demonstrate the PREE using within-subject designs have failed (e.g., Adams, Nemeth, & Pavlik, 1982; Cohen, Riley, & Weigle, 1993; Pavlik, Carlton, Lehr, & Hendrickson, 1967; Warren & Brown, 1943). In some of these studies, subjects were exposed to different reinforcement schedules alternated with extinction in a reversal design. More commonly, subjects were exposed to rapidly alternating reinforcement conditions, each paired with a distinct stimulus (i.e., the multiple schedule or multielement design). Rapid alternation of the stimuli continued during extinction, and responding in their presence was compared to determine the effects of the different reinforcement schedules. Although most studies using the reversal design have obtained the PREE (e.g., Cohen et al., 1993; Wertheim & Singer, 1964), studies using the multiple schedule design often have reported a "reversed" PREE; that is, greater resistance was observed following CRF than following INT (e.g., Adams et al., 1982; Flora & Pavlik, 1990; Mellgren & Elsmore, 1991) in addition to the conventional PREE (e.g., Hearst, 1961; Pavlik & Flora, 1993).

Both reversal and multielement designs contain potential limitations that might be attenuated with certain refinements in methodology. Although the reversal design permits a direct comparison of responding during extinction following exposure to each type of reinforcement schedule, results may be confounded by sequence effects. The reversal design necessarily exposes the subject to a history of reinforcement and extinction that can influence the outcome in two ways. First, repeated exposure to reinforcement might alter responding during subsequent extinction phases. For example, resistance to extinction might increase as the subject is exposed to an increasing number of reinforcers (Perin, 1942). Second, repeated exposure to extinction might alter responding during subsequent extinction conditions. In some cases, for example, resistance to extinction will decline across successive extinction phases (Clark & Taylor, 1960). Although order effects (i.e., history with specific conditions that influence the outcome) could be identified by varying the order of reinforcement conditions across subjects, previous exposure to reinforcement or extinction per se cannot be eliminated with this design.

The multielement design minimizes sequence effects, but it may be limited by interaction effects across conditions during either the reinforcement or the extinction phases, a problem that has been encountered in basic research on extinction (e.g., Amsel, Rashotte, & Mackinnon, 1966; Rashotte, Ross, & Amsel, 1968). For example, conditions presented during one component of

the multielement design could influence responding in a different component, obscuring any differences in the effects of INT and CRF schedules. Interaction effects across conditions of the multielement design may be less likely to occur if the reinforcement schedules are associated with highly salient stimuli (e.g., different therapists, responses, settings, or times of day). Sequence effects could be minimized in the reversal design by keeping conditions as brief as possible.

In addition to experimental design, applied studies on the PREE must include consideration of the most appropriate measures of resistance. Nevin (1988) suggested that the usual finding for both within- and between-subjects comparisons is the reversed PREE, particularly if the data are transformed to adjust for differences in response rates that are associated with different schedules of reinforcement. Rate of responding under INT schedules is often much higher than rate of responding under CRF, and this difference in response rates will carry over into the subsequent extinction phase. As such, Nevin argued that traditional measures of resistance, including response rate, number of responses, and time to meet an extinction criterion, should not be compared following baselines with INT and CRF schedules because baseline rates per se will influence response persistence during extinction. That is, behavior will appear to be more resistant to extinction following INT reinforcement because response rates are necessarily higher at the beginning of extinction following the INT schedule than following the CRF schedule. To control for the effects of baseline response rate on persistence during extinction, Nevin suggested that data on the PREE should be expressed as a proportion of the response rate during baseline or during the initial extinction sessions, and rate of decrease in responding (i.e., slopes of extinction curves) should be examined.

Nevin (1988) used this measure of resistance to reanalyze data from several previous studies on the PREE and found that responding following CRF was consistently more resistant to extinction than responding following INT reinforcement. He suggested that rate of reinforcement rather than reinforcement intermittence actually determines resistance to extinction. A number of basic studies have demonstrated a positive relationship between reinforcement rate and resistance to change (see Nevin, 1992, for a review). Thus, exposure to a CRF schedule, which is often associated with a higher rate of reinforcement than INT schedules, should generally increase resistance to extinction in the natural environment.

The purpose of this study was to examine the effects of prior exposure to CRF and INT schedules of reinforcement on responding during subsequent extinction with individuals who engage in problem behavior. To investigate the PREE, the study used both multielement and reversal designs and the measures of resistance recommended by Nevin (1988).

METHOD

Subjects and Setting

Three individuals diagnosed with profound mental retardation participated. All lived in a residential facility for individuals with developmental disabilities and were referred to a specialized program, located on the grounds of the facility, for the assessment and treatment of self-injurious behavior (SIB). Prior to the study, the subjects had not been exposed to any systematic treatment for SIB at either their residences or the specialized day program.

Brandon, a 32-year-old man, was referred for treatment due to an extensive history of head hitting that had resulted in a cauliflower left ear. He displayed no expressive language but was able to respond to a few sim-

ple requests. He could walk independently and had no visual or auditory impairment. Throughout the course of this study, Brandon received prescribed medication (chlorpromazine) for problem behavior, but no medication changes occurred until the completion of the experiment.

Sue was a 24-year-old woman whose SIB consisted of head hitting and hand biting. She did not display expressive verbal skills but was able to respond to some simple directions. She could walk independently and had no visual or auditory impairment. Sue received medication to control seizures throughout the study.

Harold was a 39-year-old man who had a variety of severe behavior disorders, including SIB (head and body hitting, hand biting), aggression, and disruption. He had some expressive verbal skills, but his speech was difficult to understand, and he could respond to simple requests. Harold could walk with assistance, although he was confined to a wheelchair. He was blind due to cataracts but had no auditory impairment. Harold received medication to control seizures throughout the experiment.

All sessions were conducted in therapy rooms at the day program. A number of Harold's sessions also were conducted at his residence (see below). Rooms contained tables and chairs as well as materials necessary for conducting certain conditions. At least one observer was present during all sessions.

Human subjects approval for this study was obtained from the University Institutional Review Board and the facility in which the day-treatment program was located. To assess SIB and examine the PREE, subjects were permitted to engage in SIB for brief periods of time. Although SIB was likely to produce extensive physical damage for only 1 subject (Brandon), routine safeguards were established to reduce the risk of injury to all subjects (see Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994).

Response Measurement and Interobserver Agreement

Response definitions were developed on the basis of staff interviews and informal observations of the subjects prior to the study. *Face, head,* or *body hitting* (Brandon, Sue, Harold) was defined as forceful contact of an open or closed hand with any part of the face, head, or other body part (e.g., leg, chest). *Hand biting* (Sue, Harold) was defined as closure of the upper and lower teeth on the flesh anywhere on the hand or wrist. *Aggression* (Harold) was defined as hitting, kicking, or biting the therapist (including attempts), and *disruption* (Harold) was defined as throwing objects or tearing clothing. Data were also collected on subjects' compliance with instructions and the experimenter's delivery of attention, instructions, or materials.

Observers collected data on the frequency of responses using a hand-held computer (Assistant, Model A102) that audibly signaled 10-s intervals. Observers were graduate and undergraduate students who had previously demonstrated proficiency with this type of data collection by attaining a 90% agreement criterion for three consecutive sessions.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during 35% of all sessions. In comparing observers' records, session time was divided into consecutive 10-s intervals, and agreement percentages were calculated on an interval-by-interval basis. The smaller number of responses in each interval was divided by the larger number of responses. These fractions were then summed across all intervals and divided by the total number of intervals in the session to get the percentage agreement between the two observers. Mean agreement scores for SIB, aggression, or disruption were 96% overall (range, 94% to 98%).

Table 1
Mean responses per minute of SIB (and aggression or disruption for Harold) across experimental conditions of the functional analysis.

Condition	Subject		
	Brandon	Sue	Harold
Alone	0	0	0
Attention	0	0	0
Materials	3.1	1.5	
Demand	0.2	0	4.1
Play	0	0	0.1

General Procedures

Prior to the study, a functional analysis was conducted to identify the variables that were maintaining subjects' SIB and other target behaviors (i.e., aggression and disruption for Harold). Subjects were exposed to four assessment conditions (alone, attention, demand, and play) presented within a multielement design, based on procedures described by Iwata et al. (1982/1994). In addition, Brandon and Sue were exposed to a fifth condition (materials) based on information obtained from interviews with staff at their residence and through informal observations. The materials condition was designed to test the effects of positive reinforcement, in the form of access to a specific item, on the rate of SIB. Prior to each session, the subject was given access to a preferred item (a game for Sue and shoes for Brandon). At the start of the session, the therapist removed the item. Contingent on each occurrence of SIB, the subject was given access to the item for 30 s. All sessions of the functional analysis lasted 15 min, and two to three sessions were conducted per day for each subject, usually 4 to 5 days per week. Table 1 shows the mean rates of SIB (and other target behaviors) observed during assessment. Results for Brandon and Sue indicated that their SIB was differentially sensitive to positive reinforcement in the form of access to a particular item. Results for Harold indicated that his SIB, aggression, and disruption were members of the same response class, all differentially sensitive to negative reinforcement in the form of escape from instructions.

Following assessment, the PREE was examined by exposing subjects to baseline conditions with CRF and INT reinforcement schedules, then comparing their performance during extinction. Extinction was implemented as the sole intervention because other treatment procedures (e.g., differential reinforcement) might have influenced behavior in a manner that would not permit conclusions about either response reduction or persistence during extinction. Two to four daily sessions were conducted for each subject, usually 4 days per week. Brandon and Sue were exposed to baseline (reinforcement) and extinction conditions alternated within a reversal design. Harold's reinforcement and extinction conditions were conducted in a multielement design, in which each condition was associated with a specific therapist, setting, and time of day.

Baseline

During baseline conditions, the therapist used either CRF or INT schedules to deliver the maintaining reinforcer following occurrences of the target response. Subjects received five reinforcers during each session. The number of reinforcers was held constant across baseline sessions because results of previous studies had indicated that amount of reinforcement can influence resistance to extinction (e.g., Perin, 1942). Thus, all sessions were equated in terms of both number of reinforcers and reinforcement time, but session time varied somewhat. For Brandon and Sue, procedures implemented during baseline sessions were identical to those implemented during the materials condition of the functional analysis. For Harold, procedures implemented during the demand condition of the functional analysis (see Iwata

et al., 1982/1994) were modified for baseline in two ways: (a) Instructions were delivered continuously throughout the session rather than on a fixed-time (FT) 30-s schedule, and (b) the contingent 30-s escape from instructions was increased to 1 min.

CRF baseline. The maintaining reinforcer was delivered following each occurrence of SIB (for all subjects), aggression (for Harold), or disruption (for Harold).

INT baseline. During this condition, reinforcement was delivered on a gradually leaner schedule across sessions until responding was maintained on a predetermined INT schedule. A number of considerations influenced the choice of the terminal INT schedule for each subject, including the types of schedules that have been used in previous applied studies on the PREE and those that appeared to be operating in the natural environment based on informal observations of the subjects prior to the study. For Brandon, Sue, and Harold, the terminal INT schedules were variable-ratio (VR) 6 (range, 4 to 8 responses), FR 3, and VR 10 (range, 5 to 15 responses), respectively. The VR schedules were constructed by writing numbers (i.e., the predetermined response requirement range) on individual slips of paper. Prior to each session, the response requirement for each reinforcement delivery was determined by randomly choosing five slips of paper from the box and adjusting the fifth number as necessary to ensure that the correct average was obtained. Harold was exposed to the CRF and INT conditions concurrently. His CRF baseline sessions were conducted during the morning by one therapist in a therapy room at the day program. His INT sessions were conducted during the afternoon by a different therapist in his residence dining room.

Extinction

During these sessions, reinforcement was no longer delivered following occurrences of the target behaviors. For Brandon and Sue, the preferred item was removed at the start of the session, and all SIB was ignored. For Harold, the instructional sequence simply continued, and all instances of inappropriate behavior were ignored. Unlike baseline sessions, however, instructions were delivered on an FT 30-s schedule to ensure that equal numbers of instructions were delivered across all extinction sessions. Session length was determined for each subject by calculating the average baseline session length. Each session lasted 10 min for Brandon and Harold and 5 min for Sue.

RESULTS

Responding during extinction following baselines with INT and CRF schedules was compared several different ways. First, data from all sessions were calculated as responses per minute by dividing the total number of responses by the number of minutes of session time. The total number of responses and sessions that occurred during each extinction phase was also calculated. As noted above, however, some authors have argued that data on the PREE should be transformed to adjust for baseline differences in responding associated with different reinforcement schedules (e.g., Anderson, 1963; Nevin, 1988). Therefore, response rates during extinction were expressed as proportions of the baseline rate by dividing the response rate for each extinction session by the mean response rate for the last five sessions of the immediately preceding baseline condition. Finally, the mean reinforcement rate under each reinforcement schedule was calculated by dividing the total number of reinforcers delivered by the total minutes of session time. Reinforcement rates were then compared to the data interpretations associated with the proportion-of-baseline measure because Nevin (1974, 1988) has suggested that reinforcement rate (rather than intermit-

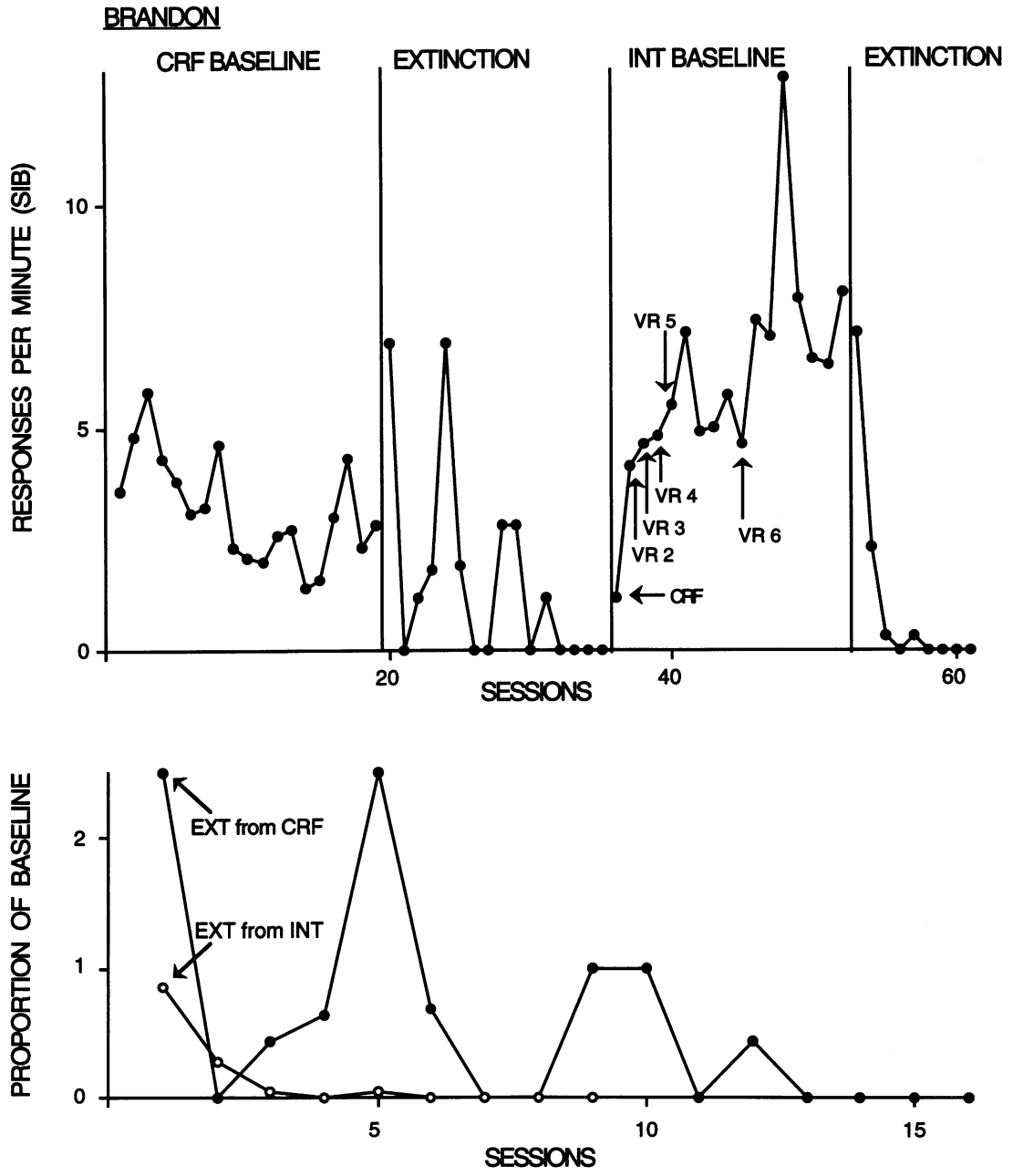

Figure 1. Rates of SIB for Brandon during baseline sessions with CRF and INT reinforcement schedules and during extinction sessions (top panel), and rates of SIB during extinction expressed as a proportion of baseline (bottom panel).

tence per se) can determine resistance to extinction.

The top panel of Figure 1 shows Brandon's response rates during all baseline and extinction sessions. Brandon was first exposed to the CRF baseline. Although a descending trend is seen during this phase, responding was fairly stable across the last eight sessions (M = 2.8 responses per minute during the last five sessions). With the

introduction of extinction, responding increased and became more variable, then decreased to zero. The extinction phase was terminated when Brandon had not exhibited SIB for four consecutive sessions; this criterion was also used as the termination criterion for the subsequent extinction phase. Brandon exhibited 255 self-injurious responses across 16 sessions (M = 1.6 responses per minute) before the first extinction phase was terminated.

The therapist then attempted to reimplement the CRF baseline to recapture responding before establishing a leaner schedule during the INT baseline phase. However, Brandon continued to exhibit no SIB for the next several days (data not shown), and, as a result, his behavior did not come into contact with the altered contingency. Brandon was then placed in a different therapy room at the treatment center. SIB abruptly reappeared in the new therapy room, and responding gradually increased as the reinforcement schedule was changed to VR 6 (M = 8.3 responses per minute during the last five sessions). During extinction, SIB rapidly decreased to zero, and Brandon exhibited only 100 self-injurious responses across nine sessions (M = 1.1 responses per minute) before satisfying the termination criterion.

The bottom panel of Figure 1 shows the data for each extinction session expressed as a proportion of the baseline response rate. Higher proportions indicate greater resistance to extinction. The proportion-of-baseline measure for the CRF extinction sessions was consistently higher than that for the INT extinction sessions. Thus, Brandon's data are indicative of a reversed PREE. Rates of reinforcement delivered under the two baseline conditions are somewhat consistent with this interpretation. That is, reinforcement rate under CRF (M = 1.2) was slightly higher than under INT reinforcement (M = 1.0).

The top panel of Figure 2 shows the results for Sue expressed as responses per minute of SIB across all baseline and extinction sessions. Sue was first exposed to the CRF baseline condition, during which rates of SIB were very stable (M = 1.7 responses per minute during the last five sessions). With the introduction of extinction, responding increased and then rapidly decreased to zero. To minimize potential sequence effects, the extinction criterion selected for Sue (i.e., two consecutive sessions with SIB at or below 0.5 responses per minute) was more lenient than that selected for Brandon. Sue exhibited just 43 self-injurious responses across eight sessions (M = 1.1 responses per minute) before satisfying this criterion. During the INT baseline phase, Sue's rate of SIB increased as the schedule was changed from FR 2 to FR 3 (M = 5.6 responses per minute during the last five sessions). The reintroduction of extinction produced a pattern of responding similar to that observed in the first extinction phase (i.e., SIB initially increased and then decreased to zero). However, Sue exhibited 301 self-injurious responses across 16 sessions (M = 3.8 responses per minute) before satisfying the extinction criterion. Thus, Sue exhibited seven times more self-injurious responses and required twice as many sessions to meet the termination criterion during the second extinction phase (following the INT baseline) than during the first extinction phase (following the CRF baseline).

The next phases were designed to replicate the previous conditions and to investigate the advantages of switching from an INT to a CRF schedule prior to treatment with extinction. During the first phase, the therapist reimplemented the INT schedule, which was changed to FR 3, and then changed the schedule to CRF. Rates of SIB during the INT baseline sessions were similar to those observed during the initial INT phase, and responding abruptly decreased with the transition from the INT to the CRF schedule.

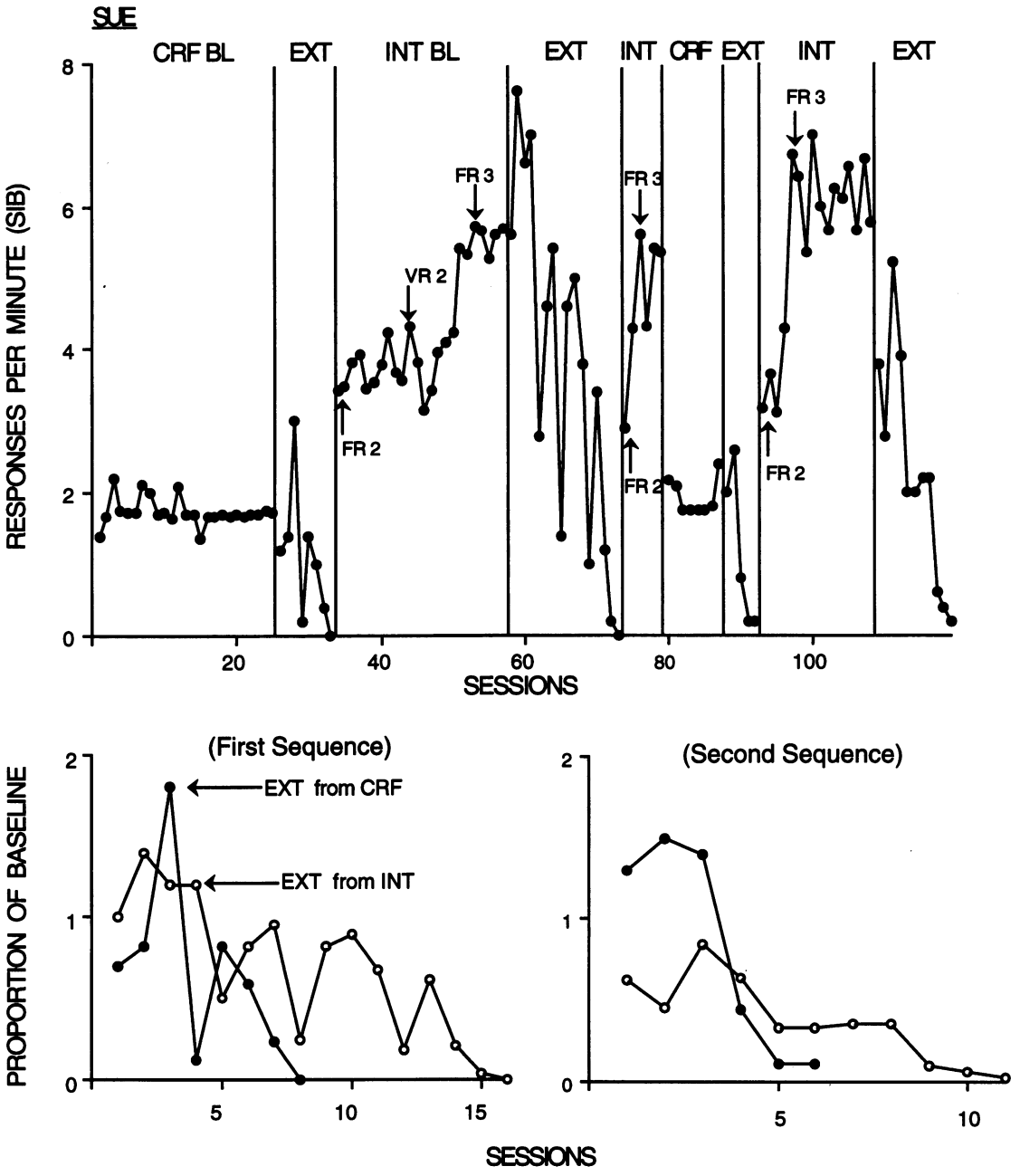

Figure 2. Rates of SIB for Sue during baseline sessions with CRF and INT reinforcement schedules and during extinction sessions (top panel), and rates of SIB during extinction expressed as a proportion of baseline (bottom panel).

Results of these phases, which replicated those obtained in the first part of the study, showed that SIB was maintained at a much higher level under the INT schedule (M = 4.6 responses per minute) than under the CRF schedule (M = 1.8 responses per minute). The introduction of extinction again resulted in an initial increase in SIB followed

by a rapid decrease to low levels. Sue exhibited 41 self-injurious responses across six sessions (M = 1.4 responses per minute) before meeting the extinction criterion. During the final phases, the INT baseline and extinction conditions were reimplemented to compare responding during extinction after INT reinforcement to responding during extinction after a switch from an INT to a CRF schedule. As the figure shows, rates of SIB during the final exposure to the INT baseline and extinction conditions were similar to those observed during Sue's previous exposures to these conditions. Sue exhibited 127 self-injurious responses across 11 sessions (M = 2.3 responses per minute) before meeting the extinction criterion. Thus, Sue exhibited about three times as many self-injurious responses and required nearly twice as many sessions to meet the termination criterion during the last extinction phase (following the INT baseline) than during the third extinction phase (following a switch from INT to CRF baseline conditions).

Although these findings suggested that responding was more persistent following INT than CRF schedules and that treatment with extinction might be improved for some individuals by switching from an INT to a CRF schedule prior to extinction, Sue's terminal rate of SIB was consistently much higher under INT reinforcement. This difference might partially account for the higher response rates, number of responses, and total number of sessions observed during extinction following the INT schedule (Nevin, 1988). The bottom panel of Figure 2 shows the data for each extinction session expressed as a proportion of the baseline response rate. The left figure displays the data from Sue's first exposure to the two reinforcement schedules and extinction, and the right figure shows the data from her second exposure. These results are somewhat ambiguous. In the left figure, the data suggest that responding was slightly more resistant to extinction following the INT than the CRF schedule; that is, the slope of the line connecting the data points from the CRF extinction sessions is somewhat steeper than the slope of the line connecting the data points from the INT extinction sessions. In the right panel, the slope associated with the CRF extinction sessions is also steeper than that associated with the INT extinction sessions. However, a comparison of the slopes may not be a useful measure of resistance in this instance. During the initial stage of extinction, the proportion-of-baseline measures for the INT extinction sessions were substantially lower than those for the CRF extinction sessions, suggesting greater resistance to extinction following CRF. These equivocal results are consistent with the finding that reinforcement rates were equivalent under the CRF and INT schedules during both exposures to the two reinforcement schedules (M = 1.7 for the first exposure and M = 1.8 for the second exposure).

Data for Harold are shown in the top panel of Figure 3 as rates of inappropriate behavior (SIB, aggression, and disruption) during the reinforcement and extinction sessions with each therapist. Results showed that responding was much higher during the INT reinforcement sessions (M = 7.1 responses per minute for the last five sessions) than during the CRF sessions (M = 1.5 responses per minute for the last five sessions). The therapists simultaneously switched to extinction in their respective settings. The extinction criterion selected for Harold was SIB at or below 0.5 responses per minute for three consecutive sessions with both therapists. That is, extinction would continue with each therapist until this criterion was met during both morning and afternoon sessions. Results for the extinction condition showed that responding following the CRF baseline initially increased and became more variable before gradually decreasing to low levels. Following the VR 10 baseline, re-

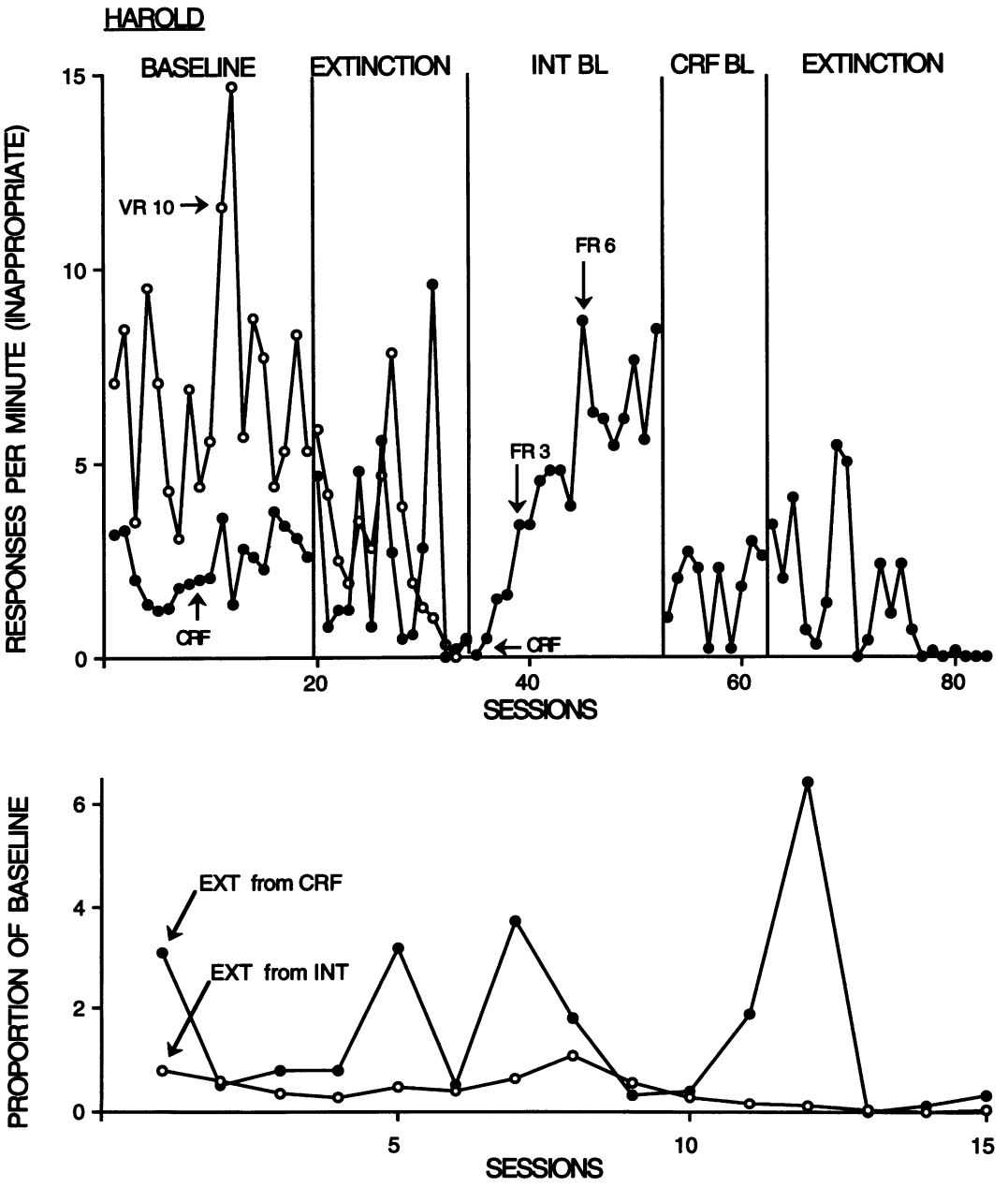

Figure 3. Rates of SIB for Harold during baseline sessions with CRF and INT reinforcement schedules and during extinction sessions (top panel), and rates of SIB during extinction expressed as a proportion of baseline (bottom panel).

sponding gradually decreased to low levels. The termination criterion was satisfied after each therapist had implemented 15 sessions. Harold exhibited 360 responses (M = 2.4 responses per minute) during extinction sessions with the CRF therapist and 419 responses (M = 2.8 responses per minute) during extinction with the INT therapist. Thus, as measured by response rates and total number of responses, persistence during

extinction following the INT baseline was slightly greater than that following the CRF baseline. However, Harold's response rate under the INT schedule was substantially higher than that under the CRF schedule, a difference that could produce an apparent PREE or even obscure a reversed PREE.

The next phases were designed to replicate the previous baseline and extinction conditions. It could be argued, for example, that rate of behavior was higher under the VR 10 baseline than under the CRF baseline because INT reinforcement was associated with a specific therapist, setting, or time of day. Thus, the therapist initially associated with the CRF baseline implemented an INT baseline (in the morning at the day program). Results showed that rates of problem behavior increased when the reinforcement schedule was gradually changed to FR 6 (M = 6.2 responses per minute during the last five sessions), and responding abruptly decreased and was maintained at a low level (M = 1.8 responses per minute) when the therapist switched to a CRF schedule. These findings replicated those of previous phases showing that response rates were much higher under INT reinforcement than under CRF. With the introduction of extinction, responding gradually decreased to near zero and remained low across seven sessions.

The bottom panel of Figure 3 displays the proportion-of-baseline measure for each extinction session during Harold's first exposure to the two reinforcement conditions and extinction. Results showed that the proportion-of-baseline measures for the CRF extinction sessions were consistently higher than those for the INT extinction sessions, indicating a reversed PREE for Harold. Further, mean reinforcement rates (0.7 under CRF and 0.4 under INT) are consistent with the reversed PREE interpretation of Harold's data.

DISCUSSION

This study investigated the clinical significance of the PREE with individuals who engaged in SIB, aggression, and disruption. Results suggested that these problem behaviors may not be more difficult to treat with extinction if they have been maintained on INT schedules rather than on CRF schedules and that texts on application may have overemphasized the potential for treatment difficulties generated by the PREE. When resistance to extinction was measured by expressing response rates during extinction as a proportion of the baseline rates (thereby controlling for the effects of baseline response rate on persistence), a clear reversed PREE was obtained for 2 subjects (Brandon and Harold) and equivocal findings were obtained for a 3rd subject (Sue).

Although these results appear to contradict those of a number of studies in which the PREE has been clearly demonstrated, the results are consistent with those of basic studies using within- rather than between-subjects designs (e.g., Adams et al., 1982; Flora & Pavlik, 1990). Factors that are responsible for conflicting outcomes among basic studies are still relatively unclear. However, results of studies using within-subject designs may be particularly vulnerable to confounding by sequence or interaction effects.

Research findings on the PREE may also be equivocal because *resistance* has been defined and measured in a variety of ways. In most basic studies, resistance to extinction has been based on response rates, total number of responses, or amount of time to meet an extinction criterion. In general, these studies demonstrated greater resistance to extinction following INT schedules than CRF schedules. Others have attempted to adjust for the differences in responding associated with the different baseline conditions by calculating the rate of change in responding

during extinction or the proportion-of-baseline response rates (cf. Nevin, 1988). Results of these studies indicated that CRF schedules were associated with greater resistance to extinction than were INT schedules. The current study provides further data showing that reinforcement schedules can produce apparently different outcomes solely as a function of the measure used to reflect resistance. When traditional measures of resistance (e.g., response rate, number of responses) were examined, a PREE was obtained with 2 subjects (Sue and Harold), whereas a reversed PREE was obtained with just 1 subject (Brandon). These findings suggest that the relationship between reinforcement schedules and responding during extinction is more complex than that depicted in many texts and articles on application.

Results of this study also demonstrated that rate of inappropriate behavior can be extremely sensitive to changes in reinforcement schedule. For all subjects, responding under INT reinforcement was consistently higher than responding under CRF, a finding that replicates those of previous studies that examined the effects of ratio schedules on response rate (e.g., De Luca & Holborn, 1992; Lovaas, Freitag, Gold, & Kassorla, 1965; Schroeder, 1972; Stephens, Pear, Wray, & Jackson, 1975). This may have resulted in the higher initial response rates during extinction following the INT baseline (see results for Sue and Harold). These findings suggest that switching from an INT to a CRF schedule prior to treatment with extinction might lower the baseline response rate as well as the total number of responses exhibited during extinction. Although caregivers may be somewhat reluctant to implement a strategy that involves deliberate reinforcement of problem behavior, the advantages may be clear when dangerous behaviors are targeted for reduction. For example, Sue exhibited only 41 self-injurious responses during extinction after the INT schedule had been switched to CRF, compared to 127 responses during extinction following an INT baseline. Although recommended by various authors as a means of attenuating or eliminating the PREE (see Ducharme & Van Houten, 1994), this treatment strategy appears to have merit based solely on response rate as a function of the baseline reinforcement schedule.

Nevin (1979, 1988, 1992) has suggested that reinforcement rate rather than the particular reinforcement schedule can determine resistance to extinction, and results of this study appear to support this hypothesis. For 2 subjects (Brandon and Harold), a comparison of the reinforcement rates delivered under the INT and CRF schedules demonstrated that the schedule associated with the higher rate of reinforcement was also associated with the greatest resistance to extinction (using the measure of resistance recommended by Nevin). This finding indicates that reinforcement rate should also be examined (and perhaps altered) in the natural environment before treating problem behaviors with extinction.

Although results of this study may have important implications for the use of extinction in applied settings, the findings should be considered preliminary due to a number of potential limitations. First, sequence effects associated with the reversal design may have been responsible for the reversed PREE and ambiguous outcome obtained for Brandon and Sue, respectively. That is, their first exposure to extinction (following CRF) may have led to a reduction in resistance during their second exposure to extinction (following INT). Results of some basic studies indicate that resistance can decrease across repeated exposures to extinction (e.g., Bullock & Smith, 1953; Clark & Taylor, 1960). In this study, extinction phases were kept as brief as possible to minimize the potential influence of sequence effects. However, data for Brandon, who had the most stringent

extinction criterion, appear to suggest the occurrence of such effects.

Second, interaction effects across conditions of the multielement design may have been responsible for the absence of a PREE for Harold. Because several basic studies have obtained the PREE when salient stimuli were associated with the different components of a multiple schedule (e.g., Feider, 1973; Waters & Knott, 1970), conditions for Harold were paired with specific therapists, settings, and times of day. Nevertheless, Harold met the extinction criterion simultaneously with both therapists, suggesting that interaction effects may have occurred during extinction. That is, exposure to extinction in the morning at the day program (following CRF) may have led to less resistance to extinction during the afternoon sessions at Harold's residence (following INT). Such an effect is not merely speculative; results of basic studies using the multiple schedule design indicate that interaction effects can occur during extinction, thus obscuring the PREE (e.g., Amsel et al., 1966).

Other factors, such as the reinforcement schedules used during the INT baselines, also may have decreased the possibility of obtaining a significant PREE in this study. For example, leaner reinforcement schedules, lengthier baseline phases, or different extinction (termination) criteria may have altered the findings. Nevertheless, the parameters implemented in this study were similar to those used in studies that have obtained the PREE.

Additional research on the clinical significance of the PREE with severe behavior disorders seems warranted. Although several studies have attempted to examine the benefits of altering reinforcement schedules while treating problem behavior (e.g., Foxx & McMorrow, 1983; Neisworth, Hunt, Gallup, & Madle, 1985; Schmid, 1986), conclusions about the effects of switching from INT to CRF schedules prior to extinction cannot be formed on the basis of their findings. In these studies, contingencies that maintained subjects' inappropriate behavior (stereotypy) were not identified, and it was assumed that the behaviors were maintained by INT schedules of automatic (sensory) reinforcement. Because sources of automatic reinforcement are difficult to manipulate, arbitrary reinforcers (e.g., food items) were delivered following each occurrence of stereotypy (i.e., on a CRF schedule) and then removed in an attempt to decrease the behavior. Results suggested that the procedure produced short-term reductions in stereotypy for some of the subjects. However, these studies demonstrated the effects of introducing and removing an arbitrary reinforcer on behavior that was maintained by an unidentified reinforcer, not the effects of switching reinforcement schedules prior to extinction (e.g., see Wylie & Grossmann, 1988).

Further studies on the PREE should attempt to determine which measures of resistance to extinction are most relevant to applied problems. Possibly, all measures included in the current study can be important, depending on the situation. For example, results of additional research might indicate that INT reinforcement is associated with more responses during extinction but faster decrements in responding (i.e., steeper extinction curve slopes) than CRF. In this case, the CRF baseline may be more desirable than the INT baseline when treating severe behaviors disorders, such as SIB, but less desirable than the INT baseline when treating other types of problem behaviors, such as mild forms of stereotypy and disruption.

Texts and articles on application (e.g., LaVigna & Donnellan, 1986; Romanczyk, Kistner, & Plienis, 1982) often describe extinction as a relatively inefficient treatment procedure that may be associated with a number of undesirable side effects, such as

initial increases in response frequency (i.e., extinction bursts) and aggression (i.e., extinction-induced aggression). As a result, extinction is rarely recommended as a singular intervention for severe behavior disorders. Nevertheless, robust treatment effects were obtained in this study by simply terminating the contingency between responding and reinforcement during brief (5- or 10-min) sessions. For all subjects, target behaviors were reduced to low levels within 16 sessions (range, 6 to 16 sessions), and few problems were noted, with the exception of response bursting during the initial stages of treatment. However, all extinction bursts were relatively brief and tended to follow CRF rather than INT reinforcement baselines. These results are consistent with those of previous studies demonstrating the utility of extinction as treatment for problem behavior (e.g., Carr, Newsom, & Binkoff, 1980; Forehand, 1973; France & Hudson, 1990; Iwata, Pace, Cowdery, & Miltenberger, 1994; Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990; Mazaleski et al., 1993; Salend & Meddaugh, 1985).

Basic research findings suggest that a variety of factors other than reinforcement schedules can influence performance during extinction (Mackintosh, 1974). Further examination of these factors, including reinforcer magnitude, reinforcement delay, and response effort, could lead to the development of a comprehensive technology for the use of extinction in applied settings.

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STUDY QUESTIONS

1. What is the PREE and what is its relevance to the use of extinction in clinical situations?

2. The formula for calculating interobserver agreement scores was different than that typically used, in which agreements (on occurrence-nonoccurrence or exact frequencies) are divided by agreements plus disagreements. How would results obtained from using this formula compare with those obtained if (a) the occurrence-nonoccurrence method or (b) the exact-agreement method were used?

3. How were the INT baselines (schedules) produced, and how were the CRF and INT baselines equated?

4. What experimental designs were used for evaluating the PREE and why were the designs varied across subjects?

5. Briefly describe the manner in which extinction was implemented for each of the subjects. Also, why was extinction used as the sole intervention and why might this fact limit the generality of the authors' findings with respect to typical clinical application?

6. What measures have been used to quantify resistance to extinction, and which of these adjusts for differing rates of responding observed during baseline? Which measures were reflected in the results presented?

7. In comparing data shown in the top and bottom panels of each figure, what conclusions are supported about the presence of the PREE?

8. Based on the results obtained, the authors suggested that the PREE may not be as prevalent as has been suggested in the applied literature. Nevertheless, they suggested that it may be advantageous to expose behavior to CRF schedules of reinforcement prior to implementing extinction. What was the basis for this recommendation?